III Other Evidences of Mountain Building

Topic 7 Uplifting

Not all sedimentary rock layers of passive continental margins are crumpled into folds. In some areas the layers are raised to higher levels with little deformation. Such uplifting is also a part of mountain building. Several methods can be used to determine whether uplifting has occurred.

Fossils are one indicator of uplift. Some of the sedimentary rocks of passive continental margins contain the skeletons and shells of organisms that lived in the ocean. The presence of these marine skeletons and shells in rocks now located high above sea level is good evidence that uplifting has occurred.

A second evidence of uplift comes from *raised beaches*. In some coastal areas of the world, old shorelines can be seen at elevations above the modern shoreline. One particularly well-developed area of old shorelines is the coast of California near Los Angeles. Here a series of level terraces can be seen, each above and inland from the previous one. The terraces are old beaches that originally formed at sea level. Each must have been raised above sea level as the area was uplifted. Since the highest is about 400 meters above the present sea level, the area must have been uplifted by at least that amount.

A third evidence of uplift can be obtained by making regular *measurements of the elevation* of an area over a period of time. Using bench marks (Chapter 7, Topic 8), a surveying team can determine whether any changes in elevation have occurred since the last survey. Using this technique, a mountain pass 80 kilometers east of Los Angeles has been found to be uplifting at a rate of about 14 centimeters per century. Another area within 3 kilometers of the San Andreas Fault has been rising at a rate of 78 centimeters per century.

Topic 8 Tilting

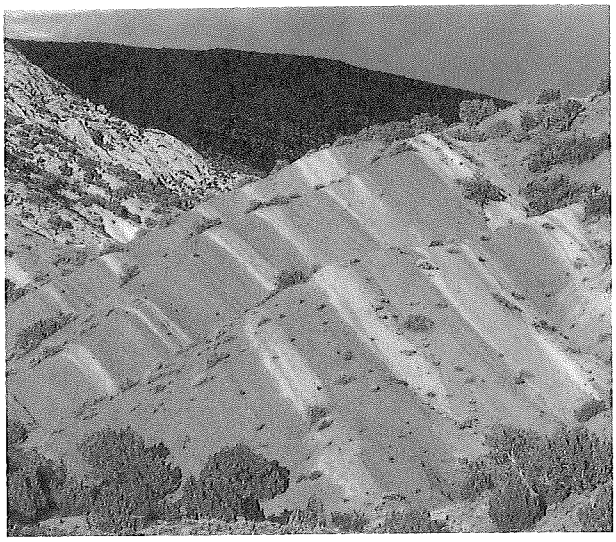
Most sedimentary rocks are formed in level layers. Therefore, the occurrence of tilted layers is an evidence of mountain building.

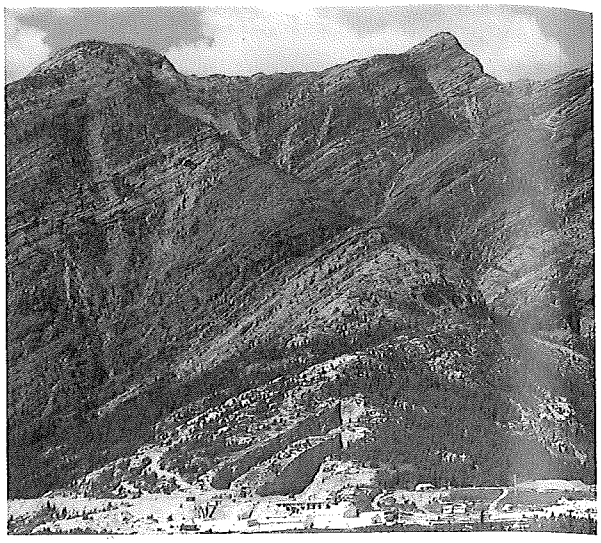
Layers of rock can become tilted in a number of different ways. The folding of sedimentary rocks into anticlines and synclines is one way. The folded layers of the Valley and Ridge Province of the Appalachian Mountains contain many examples of tilted sedimentary rock layers. Tilting can also result when rocks are pushed upward. The uplift of the Rocky Mountains caused sedimentary layers in Colorado to be steeply inclined.

OBJECTIVES

- **A** Name and describe three ways in which uplifting of rock layers can be detected.
- **B** Identify some ways in which rock layers become tilted; describe and give examples of fault-block mountains.
- **C** List and describe several ways to tell if rock layers have been overturned.

16.6 These raised beaches along the California coast are evidence of uplifting.





16.7 (left) The tilted layers of this sandstone formation indicate that a geologic change has occurred. (right) Fault-block mountains are usually quite steep on the faulted side.

In other areas, tilted layers are the result of whole blocks of crust having been faulted and uplifted at the same time. The raised structures are called **fault-block mountains.** Such mountains are usually steep on the faulted side but gently sloping on the opposite side. Examples of fault-block mountains are the Sierra Nevadas of California, the Wasatch Range of Utah, and the Teton Range of Wyoming. In addition, a series of fault-block mountains can be seen in Nevada and western Utah.

Topic 9 Overturning

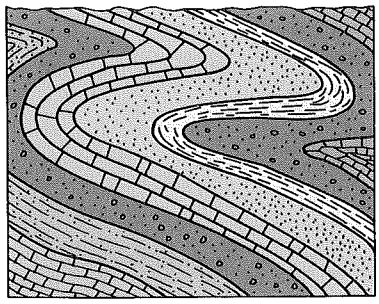
In some areas of the world, rock layers are so severely tilted that they may be bottom side up. Geologists have several methods of determining whether rock layers have been overturned.

Ripple marks are features that form on the floor of a quiet body of water when waves are moving gently across the surface. These features consist of miniature valleys between sharply pointed tiny hills. The rock containing ripple marks is right side up if the sharp hills point up.

Cross-bedding is a feature of deltas, sand dunes, and migrating ripples. Although most sediments are deposited in level layers, parts of deltas and sand dunes are not. These parts are deposited at an angle to the other level layers and can sometimes be used to tell if the entire layer has been overturned. The layer is right side up if the cross-bedding curves downward and the top of the cross-bedded layer is cut off by the layers above it.

Mud cracks develop on the surfaces of such areas as mud flats when the mud and ooze dry. Individual cracks are wider at the top than at the bottom. When these cracks are preserved in rocks, they are still wider at the top if the layer is right side up.

Shells with curved surfaces, such as clam shells, are unstable if their open side is up. Currents in the water tend to flip over such shells. These shells, however, are very stable if the open side of the shell is down. A layer in which most of the curved shells have their open sides down is right side up.



16.8 Some rock layers can become so severely tilted that they are overturned.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

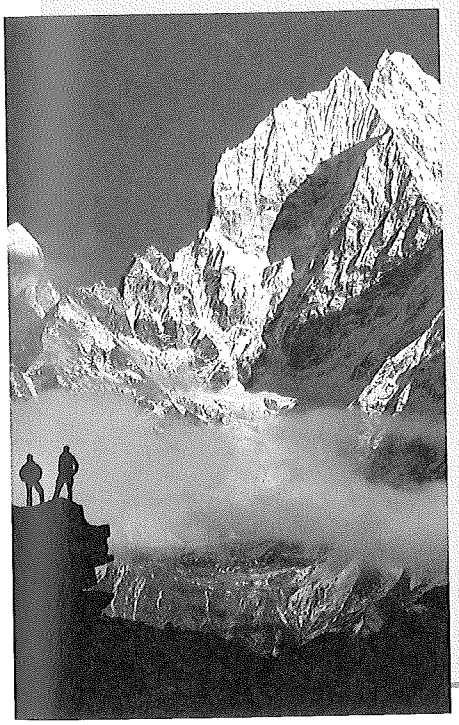
7. **(a)** How do the fossils of organisms that lived in the ocean show that uplifting has occurred? **(b)** How do old beaches on the California coast show uplifting? **(c)** At what rate have changes in elevation occurred near Los Angeles and near the San Andreas Fault?

8. **(a)** In what position are most sedimentary rocks formed? **(b)** List two ways in which sedimentary rocks can be tilted. **(c)** What are fault-block mountains? **(d)** Give some examples of fault-block mountains including a large area where many occur.

9. **(a)** What is meant by overturning? **(b)** List some sedimentary features that indicate whether overturning has occurred and describe the appearance of each feature if overturning has not occurred.

Current RESEARCH

Tracking the Moving Plates



Don't panic, but the ground beneath your feet is *moving*. The movement is too slight for you to detect, but Earth's lithospheric plates are slowly moving toward or away from one other, creating the forces that cause earthquakes and build Earth's great mountain chains.

Until recently, scientists had no way to directly measure a plate's movement. Now satellites are being used to track the plates' slow progression. The technique used is called satellite laser ranging (SLR). Scientists direct a laser beam from Earth's surface toward a satellite that is covered with reflecting prisms. These prisms bounce the light directly back to its point of origin. By timing how long it takes the light to make the round trip to and from the satellite, scientists can use the speed of light to calculate the distance to the satellite. A comparison of measurements taken over several years provides data on how the location of the ground station has changed, which tells how quickly the plate on which the station is located is moving.

For example, direct measurements from the satellite *Lageos I* show that the Hawaiian island of Maui is moving toward Japan at a rate of about 7 centimeters per year. Maui is moving away from South America at a rate of about 8 centimeters per year. Even this gradual movement of the Pacific Plate will become substantial over the broad expanse of geologic time. Since Pangaea broke apart 180 million years ago, North America and Europe have been moving apart at a rate of about 3 centimeters per year. Now the two continents are separated by a distance of nearly 5000 kilometers!